L-BAND CONTRIBUTION TO C-BAND INSAR STUDIES OF AFRICAN VOLCANIC AREAS

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1. INTRODUCTION

Study and monitoring of active volcanic areas in Africa can be problematic using ground-based methods, due to political and security tensions or difficulties in field accessibility. Remote-sensing techniques, particularly C-band Differential Synthetic Aperture Radar Interferometry (DInSAR) are therefore very useful, and provide robust observational material and tools for hazard assessment. Although C-band DInSAR suffers from vegetation-induced temporal decorrelation, as commonly encountered in equatorial regions and fertile volcanoes, this can be partly overcome by using a systematic SAR monitoring procedure as shown by [1, 2, 3]. Using a larger wavelength is another possibility to overcome this problem. We will show here the contribution of L-band interferometry, and advantages for using InSAR data fusion techniques, on some active African volcanic zones: Lengai-Gelai (Tanzania), Nyiragongo-Nyamulagira (Democratic Republic of Congo) and Canary Islands (Spain).

2. INSAR RESULTS

The Natron basin located in the eastern branch of the east African Rift (EAR) in Northern Tanzania was struck by a seismic crisis in July-August 2007, culminating with a Mw 5.9 event on 17 July. ENVISAT C-band interferograms captured this continental rifting event revealing complex episodes and associated ground displacement patterns [4]. The large number of fringes (phase cycles representing ground displacement of 2.8 cm in the satellite line of sight) was in some places affected by vegetation-induced decorrelation, which complicated phase unwrapping, interpretation and deformation modelling [5]. The ALOS ADEN 3690 ESA project ensured that the Natron Tanzanian seismo-magmatic crisis was captured by the ALOS satellite. ALOS interferograms were computed with the open source DORIS software [6]. In comparison to the C-band interferograms spanning the event, the coherence of the ALOS interferograms is better, and spatial aliasing disappeared due to the larger wavelength. The ALOS observations also help constraining the chronology of the complex sequence of events. A numerical modeling [7] optimization is indeed applied exploring the possibilities of combining all possible data of a certain event in order to create artificial interferograms with decreased temporal baseline [5]. Moreover, the combination of the C- and L-band information improved the unwrapping process with a method that aims at data combination of different sensors by means of data fusion [5].

In the western branch of the EAR, in the Democratic Republic of Congo, the Nyiragongo 2002 eruption was captured by ERS and RADARSAT [8] interferograms. Previous study based on ERS interferograms [9] showed that at least two deformation sources are needed to explain the interferometric signals observed over the Nyiragongo and Goma areas: most likely a dyke associated to the eruptive fissures in combination with a normal fault parallel to the East African rift close to the city of Goma. A fringe pattern in the western and south-western parts of Nyamulagira probably requires a third deformation source in this area. Unfortunately critical information is missing due to the temporal decorrelation affecting large areas of the interferograms. A time series-method based on a wavelelet analysis [10] will be applied to the five independent ERS interferograms in order to get the best coherence for this ERS dataset. To better constrain the sources characteristics, we also plan to upgrade the previous study [9] with simultaneous inversion of InSAR data from ERS (ascending orbit) and C-band RADARSAT (ascending ST6 and descending ST4 orbits). The three InSAR datasets will be unwrapped, subsampled at circular gridded points and conjointly inverted. ALOS interferograms computed for this area at time of writing, do not show any deformation, in agreement with the lack of seismic and volcanic activity. Nyamulagira volcano, with an eruption every other year on average, is however very likely to erupt in the next months, as the last eruption was in 2006. The very small amount of Nyamulagira eruptions successfully studied by InSAR since the launch of ERS-1, only two clearly revealed by C-band InSAR for a total of six eruptions, is to be attributed to the high decorrelation rate induced by the equatorial vegetation covering most of the area. A JERS-1 previous study [11] already showed better correlation for the dense vegetated flanks of the volcano, next Nyamulagira eruption is therefore expected to be captured by ALOS/PALSAR sensor.

Canary Islands are studied by C-band InSAR [12], and localised deformation events were successfully studied in Tenerife (Canary Islands) as shown by [13]. As parts of these islands are decorrelated with ERS sensor and often not monitored by ground-based network, ALOS/PALSAR sensor can therefore bring information missing with C-band monitoring. Due to the decreased fringe rate, small surface displacements as studied previously [13] could however be difficult to detect in L-band interferograms.

3. CONCLUSIONS AND PERSPECTIVES

The combination of data from several SAR sensors and modes is most promising for studying tectonic or volcanic deformation events like for the Natron crisis for which ALOS and ENVISAT data are successfully combined [5]. Time-series methods should be applied if several independent interferograms are available to optimize InSAR information.

Soon end life of ENVISAT satellite (at least in the current constellation) will be a serious thread to ensure the InSAR monitoring and study of the previously mentioned volcanic sites. RADARSAT-2 satellite can of course fill the about one year gap, prior Sentinel arises, but it is a commercial satellite for which data cost could limit its use in routine monitoring. The ALOS Systematic Observation strategy ensures a global coverage and, thanks to larger wavelength, overcomes a major part of temporal decorrelation problems. However, the long revisiting cycle is a problem for discriminating between potential multiple or non instantaneous events. The PALSAR smaller line of sight range precision (about 1.5 times worse than ERS [14]) is another limitation for accurate displacement measurements. ALOS also allows using interferograms with a larger time span than C-band sensors, and also larger spatial baseline due to higher critical baseline value. To overcome the lack of high temporal revisit for a specific area, the FBD ALOS data can also be used to be combined with FBS data and therefore increase the ALOS/PALSAR database for each studied area. ALOS processing with InSAR open-source softwares such as DORIS [6] or ROI-PAC [15] need to be upgraded to overcome the new technical issues of ALOS sensor (such as PRF updates and Actual Doppler focusing geometry). In addition to the three volcanic areas mentioned in the introduction part, other volcanic zones will also be studied by means of ALOS/PALSAR interferometry: Mount Cameroon, Fogo (Cape Verde), and Rungwe area (Tanzania) in order to try getting information about potential ground displacements in dense vegetated areas decorrelated in C-band interferograms. Several QUADPOL data are also available on these sites and would probably be exploited by means of POLINSAR technique in the near future.

4. REFERENCES

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